International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 4 Issue 4, April 2015

Forecasting Electrical Load for Home Appliances using Genetic Algorithm based Back Propagation Neural Network

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***Abstract*— The combining usage of genetic algorithms and artificial neural networks, were originally motivated by the astonishing success of these concepts in their biological counterparts. Despite their totally deferent approaches, both can merely be seen as optimization methods, which are used in a wide range of applications. "Genetic algorithms (GA) are good at taking large, potentially huge search spaces and navigating them, looking for optimal combinations of things, solutions you would find difficult to accomplish." A genetic algorithm (GA) is an iterative search, optimization and adaptive machine learning technique premised on the principles of Natural selection. They are capable to finding solution to NP hard Problems. Neural Networks utilizing back propagation based learning have promisingly showed results to a vast variety of function and problems. *Electrical load forecasting* is one such classical problem for computation. This paper presents the application of GA based Back propagation Network for long term load forecasting in power system. This problem is formulated as optimization problem. Advantages and disadvantages of this algorithm are reported and discussed.**

***Index Terms*—Genetic Algorithm, Neural Network, Electrical Load Forecasting, Neural Network Parameter**

I. Introduction

A genetic algorithm is a search method that functions analogously to an evolutionary process in a biological system. They are often used to find solutions to optimization problems. GAs are Randomized search and optimization technique guided by the principle of natural genetic systems. Currently, these algorithms are being highly considered in those

Problems with complex solution spaces for those which we do not have good algorithms to solve them [1-5]. Genetic algorithms are algorithms that combine search algorithms with the genetics of nature. Past data and Result is used to determine future results, in a 'survival of the fittest' kind of way. In a generation, the elements (the data represented as a string) that work the best move on to a new generation, with some mutations added in, just in case some important piece of information is lost through these changes. In a GA, a solution of our problem is called individual. In essence, it consists of maintaining a population of a given number of individuals, each one of them characterized by a genetic code (genotype) that identifies it univocally; thus an evolution of such population is simulated during the course of time, based on the apparition of new individuals resulting from crossovers, mutations and direct reproductions[5] of the parents. An evaluation or objective function plays the role of the environment to distinguish in each generation that relatively good solutions reproduce, and that relatively bad solutions die, to be replaced by offspring of the good. Basically, we can say that a GA is based on the following components, for any type of application: a "genetic" representation of solutions to the problem; a way to create an initial population of solutions; an evaluation function to measure the fitness of any solution, and plays the role of the environment, in which the better solutions may have greater probability of survival; "genetic" operators that effect the composition of children during reproduction; value for the parameters that the algorithm uses to guide its evolution: population size, number of generations, crossing and mutation probabilities, etc[6-12].GA,NN and FL ,each of the technologies, in their own right and merit, has provided efficient solution to a wide range of problem. Objective of the hybridization has been to overcome the weakness in one technology during its application, with the strengths of the others by appropriately integrate them. It investigates better methods of problem solving. Hybrid systems have a tremendous potential to solve problem. Inappropriate use of technology can backfire. It has ability to locate the neighborhood of the optimal solution quicker than other conventional search strategies.

***Manuscript received April, 2015*.**

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II. Electrical Load Forecasting

A. *Electrical Load Forecasting – The Problem*

The Electrical Load Forecasting problem[8] is a classic searching problem. In practical terms the problem can be thought of as that of an electrician who wishes to perform an electric load to forecast, using customers house size, air conditioning capacity and appliance capacity. It is the most famous example of an intractable (NP-complete) problem. For a capacity of N electric lamp, it's very difficult to find out the possible usage of electric power. So the number of possible solution is so immense that a computer evaluating a million possibilities per second to search through them all. A genetic algorithm can be used to find a solution is much less time[13-19]. Although it probably will not find the best

ISSN: 2278 – 1323

solution, it can find a near perfect solution in less than a minute. This application discussed by Montgomery and askin, investigates the factors which influence the load or demand for electricity by residential customers. The factors identified are: x1 – the size of the customers' house, x2 – the annual family income, x3 – the tons of the air conditioning capacity, x4 – the appliance index for the house, and x5 – the number of residents in the house on a weekday.
However in this problem we have only considered the influence of x1, x3 and x4 on the load y.The GA based BPN has a configuration 3-2-1 since three inputs are x1, x3, x4 and the output is y.

Here we have considered a sample set of x1, x3, x4 and the corresponding y values which have been normalized to lie between 0 and 1.The weight matrix determined by the BPN after 100 generation using program developed by C++.

III. Implementation of GABPN

Now, we shall develop a GABPN with real value coding for solving the Electrical Load Forecasting problem.

A. Parameter of GA

Genetic Algorithm (GA) depends on some parameters like population size, maximum generation number, probability of crossover, a goal condition and probability of mutation [2]. In our present study, we have taken the values of those parameters as follows: pop size = 20, crossover rate = 0.8, mutation rate = 0.10, maximum generation =100.

B. Initialization

For the Traveling Salesman Problem, here we have taken binary encoding to generate initial random population. Initial random population is depend upon the number of cities depending upon that we will initial population. The initialization of any component of a chromosome can be done by random initialization, as the boundary of each component is not specified in the problem. The BPN Network configuration is l-m-n (l input neurons, m hidden neurons and n output neurons) so the values of l, m and n is 5.Here the Number of weights are (l + n) m = 50, the Gene Length is d = 2 and Chromosome length L = (l + n) *md = 100 [2].

C. Random Population

The objective of this method is to start or create initial random population. The name of the method signifies the work it has to do in program life cycle. Its basic aim is to populate the chromosomes. There are no arguments to this method. In this method, first the random number generator is initialized be its appropriate seed [2]. Then for number of chromosomes and for number of bits time the module to generate the random number for the bit string object of parent chromosome and to store them in it is repeated. The method can be of form,
The Algorithm can be of the form:

1. Initialize the seed of random number generator.
2. for the entire parent chromosome do
3. For the entire bit single chromosomes do
  3a. Generate random number according to the encoding scheme
  3b. Assign this value to the bit of the chromosome.
4. End

D. Intermediate Population

Objective of this method is to select best parents for reproduction and generating new chromosomes. The name of the method signifies the work it has to do in program life cycle. Its basic work is to create an intermediate population, by choosing best parent chromosomes for reproduction process [2].
The Algorithm can be of the form:

1. for the entire parent chromosome do
  1a. map the probability of selection on roulette wheel
2. for the entire parent chromosome do
  2a. generate a random number
  2b. for all parent chromosomes do
    2b.1 if random number in the range of any parent chromosome
    2b.1 (a) mark parent
  2c. store the marked chromosome in intermediate population
3. End

E. Extract Weights

To determine the fitness values for each chromosome, we extract weight from each of chromosomes [2].

Let X1, X2…Xd …XL representing a chromosomes and Xkd+1, Xkd+2…X (k+1) d representing the kth gene in the chromosomes

F. Fitness Value

We first randomly generated the initial population Po of size P = 40 which represents the 40 chromosomes of Po. (Chromosomes are C1, C2…C40). Let W1, W2 …….W40 be the weight sets extracted from each of Ci (i = 1 to 40). For the fixed weight set Wi, the BPN is trained for the entire input instance given.

Let O1, O2, and O3 be the calculated outputs of the BPN. The root mean square of the error is

$$E = Sqrt\,[(E1+E2+E3) / 3]$$

The fitness F1 for the chromosomes C1 is given by

$$F1 = 1 / E$$

G. Reproduction

In this phase, the mating pool is first formed, before the parent chromosomes reproduced to deliver offspring with better fitness. For the given problem, the mating pool is first formed by excluding those chromosomes C1 with the least fitness Fmin and replacing it with a duplicate copy of the chromosomes Ck reporting the highest fitness Fmax. That is, the best-fit individuals have multiple copies while fit individuals die off.

H. Mate Pool

Consider the initial population of chromosomes Po generated earlier, with Fi, where i = 1 to 40.Let Fmax = Fk and Fmin =

Fl, be the maximum and minimum fitness values. We remove all chromosomes with a fitness values Fmin and replace it with copies of chromosomes whose fitness values is Fmax [2].

I. Convergence

For any problem, if the GA is correctly implemented, the population evolves over successive generation with the fitness value increasing towards the global optimum. Convergence is the progression constitutes the population share the same fitness values.

The population P1 now undergoes the process of selection, reproduction and crossover. The fitness values for the chromosomes in P1 as computed, the best individual replicated and reproduction carried out using two point crossover operators to form the next generation P2 of chromosomes. The process of generation proceeds until at one stage 95% of chromosomes in the population Pi converge to the same fitness values. At that stage, the weights extracted from the population Pi are the final weight to be used by the BPN.

J. Crossover

Objective of this method is to apply the main operator of reproduction (i.e. Crossover) to the chromosomes of intermediate population. The name of the method signifies the work it has to do in program life cycle [3]. Its basic work is to produce crossover between each paid of parent chromosomes. This is analogous to the crossover process in biological reproduction. The most general method is single point cross over. This method takes parent chromosomes from intermediate population, selected by roulette wheel or any other selection technique, and then at a particular random point, these chromosomes are crossed. So, the region after the cross point in both chromosomes are interchanged. This crossover process is Probabilistic. The maximum probability of selection will decide, whether there should be crossover or not.
The Algorithm can be of the form:

1. for the entire parent chromosome do
1a. toss the coin for crossover
1a.1 if random number below probability of crossover
1a.1 (a) generate random number for crossover point
1a.1 (b) for bits after cross point
1a.1 (b). (i) Interchange bits between parent chromosomes
2. End

K. Mutation Operator

Objective of this method is to randomly change one of the bits in the parent chromosome bit string after crossover. The name of the method signifies the work it has to do in program life cycle. Its basic work is to randomly change information encoded in the chromosome bit string structure. This is same as biological mutation, in which sometimes error is generated during the reproduction process there are mainly two different mutation techniques, which can be implemented in this method as its basic algorithm. The most general method is single bit mutation. In this method, the coin is tossed to get the probability of mutation. If it lies below the specified range, the parent chromosome's bit string is mutated at random point. Generally, the probability of mutation is kept very low. This is a very good operator, as it exploits Global Optimum The Algorithm can be of the form:

1. for the entire parent chromosome do
1a. generate a random number for probability of mutation
1a.1 if number within range
1a.1 (a) generate random mutation point
1a.1 (b) mutate the bit
2. End

IV. EXPERIMENTS AND RESULTS

We use the Genetic Algorithm based back propagation network to solve the Electrical load forecasting problem. Here are the general results for the near-optimum solutions. We set the parameters, as Crossover Rate is 0.8; Mutation Rate is 0.3.Here we are getting results using simple Genetic Algorithm based Back Propagation Network.

Table 4.1 Sample Training Set

Sample Training Set for the electrical load forecasting problem			
x1	**x3**	**x4**	**y**
0.475	0.2143	0.5577	0.4761
0.6434	0.9286	0.6718	0.7861
0.5755	0.5714	0.6089	0.6371
0.6789	0.5714	0.6602	0.6647
0.3443	0.1423	0.3306	0.2982

Where x1 is size of customers' house, x3 is tons of the air conditioning capacity and x4 is appliance index for the house and y is corresponding values of x1, x3 and x4.Here we have take sample training set for the electrical load forecasting problem. Here we have three input values x1, x3, x4 and value of y is expected.

<u>IH Layer Weights</u> <u>HO Layer Weights</u>

$$\begin{pmatrix} -0.755 & -4.082 \\ -2.51 & 4.062 \\ -0.529 & 2.789 \end{pmatrix} \quad \begin{pmatrix} -4.977 \\ 1.659 \end{pmatrix}$$

The above matrix shows the 3*2 matrix of input – hidden layer weight matrix and 1*2 matrix of hidden – Output weight matrix Which is calculated by the weight extraction algorithm.

Table 4.2 Value of Y generated by GABPN

Sample testing set, the expected, and calculated Y values by the GA & GABPN					
x1	x3	x4	Y Expected	Y by GABPN	Y by GA
0.475	0.2143	0.5577	0.4761	0.46705	0.5897
0.6434	0.9286	0.6718	0.7861	0.59559	0.7466
0.5755	0.5714	0.6089	0.6371	0.79923	0.7566
0.6789	0.5714	0.6602	0.6647	0.34498	0.5629
0.3443	0.1423	0.3306	0.2982	0.64507	0.7843

ISSN: 2278 – 1323

Table 4.2 shows the input with expected output and with output generated by the GA & GABPN. Finally its show the better result as compare to expected result. GA based BPN shows less electric power required as compared to expected power consumption. By giving the inputs of x1, x3, and x4 we are getting better result of y as compared to Expectation. By observing the value of Y generated by GABPN in Table 4.2, its better as compare to Y generated by GA.

V. Conclusion

The great weakness of this conventional algorithm, in common with other heuristic approaches, there is no way to determine how far we are from the optimal solution. A genetic algorithm based BPN can be used to find a solution is much less time. Although it probably will not find the best solution, it can find a near perfect solution in less than a minute. From all result obtained, we can conclude that the Genetic Algorithm based back propagation is best search method as compared to the other conventional methods.

REFERENCES

[1] Goldberg, D.E. "Genetic algorithms in search, optimization, and machine learning", Pearson Education, 2001

[2] Vijyalakshmi Pai G.A. & Rajasekaran S. Neural networks, fuzzy logic and genetic algorithms, Synthesis and applications. Reading, Prentice-Hall of India, 2004

[3] Man Mohan, Gupta P.K . Problems in operations research, Methods and Solutions. Reading, Sultan Chand and Sons, 1992

[4] Tapojit Kumar, Susan M. Schilling, "Comp- arison of optimization techniques in large scale Transportation Problems"

[5] R. K. Gupta, A. K. Bhunia, "An Application of real-coded Genetic Algorithm for integer linear programming in Production-Transportation Problems with flexible transportation cost ", AMO-Advanced Modeling and Optimization, Volume 8, Number 1, 2006

[6] A. Ganatra, G. Panchal, Y. Kosta, C. Gajjar, "Initial classification through back propagation in a neural network following optimization through GA to evaluate the fitness of an algorithm," International Journal of Computer Science and Information Technology, vol. 3, no. 1, pp. 98–116, 2011.

[7] G Panchal, D. Panchal, A. Ganatra, Y Kosta, "Performance analysis of classification techniques using different parameters," Springer Verlag-Germany (Springer-LNCS), vol. 6411, 2010.

[8] G. Panchal, A. Ganatra, Y. Kosta, D. Panchal, "Searching most efficient neural network architecture using Akaikes information criterion (AIC)," International Journal of Computer Applications, vol. 1, no. 5, pp. 41–44, 2010.

[9] G. Panchal, "Forecasting Employee Retention Probability using Back Propagation Neural Network Algorithm," IEEE 2010 Second International Conference on Machine Learning and Computing (ICMLC), Bangalore, India, pp. 248–251, 2010.

[10] G Panchal, A Ganatra, Y Kosta, D Panchal, "Behaviour analysis of multilayer perceptrons with multiple hidden neurons and hidden layers," International Journal of Computer Theory and Engineering, vol. 3, no. 2, pp. 332–337, 2011.

[11] G. Panchal, A. Ganatra, P. Shah, D. Panchal, "Determination of overlearning and over-fitting problem in back propagation neural network," International Journal on Soft Computing, vol. 2, no. 2, pp. 40–51, 2011.

[12] G. Panchal, A. Ganatra, P. Shah, Y. Kosta, "Unleashing Power of Artificial Intelligence for Network Intrusion Detection Problem," International Journal of Engineering Science and Technology., vol. 2, no. 10, 2010.

[13] G. Panchal, D. Panchal, "Solving NP hard Problems using Genetic Algorithm," IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 6 (2), 1824-1827, 2015.

[14] G. Panchal, D. Panchal, "Efficient Attribute Evaluation, Extraction and Selection Techniques for Data Classification," IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 6 (2), 1828-1831, 2015.

[15] G. Panchal, A. Ganatra, D. Panchal, Y. Kosta, "Employee Retention Probability using Neural Network Based Back Propagation Algorithm," IEEE Xplore, vol. 248, 2010.

[16] G. Panchal, D. Panchal, "Hybridization of Genetic Algorithm and Neural Network for Optimization Problem", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), Vol. 4 (4), 2015

[17] G. Panchal, Y. Kosta, A. Ganatra,D. Panchal, "Electrical Load Forecasting Using Genetic Algorithm Based Back Propagation Network," in 1st International Conference on Data Management, IMT Ghaziabad. MacMillan Publication, 2009.

[18] G. Panchal, A. Ganatra, "Classification and Optimization to Evaluate the Fitness of an Algorithm." Lambert Academic Publisher, Germany, 2012.

[19] G. Panchal, A. Ganatra, "Optimization of Neural Network Parameter using Genetic Algorithm". Lambert Academic Publishing, Germany, 2012.

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